IN THE DRAWINGS

In the drawings, please cancel, without prejudice, FIG. 20 for the sake of clarity. Please note that corresponding specification amendments are proposed in connection to the cancellation of said figure.

REMARKS

Applicant is grateful for the attention given the subject application resulting in allowance of independent claim 31. The drawings, specification and claims are hereby amended, with consideration and entry of the amendment, courteously requested.

Prior to a discussion of the subject amendment, some general remarks are warranted in connection to prosecution efforts to date and the published U.S. national application, namely, U.S. Pat. Appl. Pub. No. US 2006/0176302, dated August 10, 2006.

During international phase proceedings of the subject national phase application, an Art. 34 amendment was filed September 27, 2004 as part of Applicant's paper captioned RESPONSE TO 1ST WRITTEN OPINION. Both the specification and claims were amended, the pertinent pages thereof, i.e., pp. 1-16, herewith as **ATTACHMENT A**. The IPER mailed February 28, 2005 indicated that pages 35-47, (i.e., the amended claims) "filed with the letter of 27 September 2004" formed a basis of the report (i.e., the claim amendment was entered), with pages 1-34 of the description as originally filed likewise forming the basis of the report (i.e., the specification amendment appears not to have been entered).

Accompanying national phase entry was a paper captioned PRELIMINARY AMENDMENT & RESPONSE TO IPER IN US NATIONAL PHASE dated April 27, 2005. Amendments were generally directed to the drawings, the specification, and the claimed subject matter (i.e., amendment of

claims 34, 36-45, 47 and 48 of pending claims 1-17, 19-28, 30-50), pertinent pages thereof, i.e., pp. 1-25 and "Annotated Marked-Up Drawings" 2/20 and 7/20, herewith as **ATTACHMENT B**. The outstanding Official Action indicates that it is "[r]esponsive to communication(s) filed in 17 November 2003," Status Box 1 of the Office Action Summary. Presently, there is no indication that either the claim or specification amendments have been entered.

Finally, in furtherance of Applicant's RENEWED PETITION UNDER 37 CFR 1.497(D) filed March 30, 2006, please be advised that Nathan T. Hayes is the sole inventor (see DECISION ON RENEWED REQUEST UNDER 37 CFR 1.497(D) dated April 14, 2006, herewith as **ATTACHMENT C**). It is respectfully submitted that any letters patent issuing from the subject application, or divisional thereof, is to be issued solely in the name of inventor Nathan T. Hayes.

In connection to the published U.S. national application, there are a few departures in that document when compared to the published international application, namely, WO 2004/046881 A2. For instance, in ¶0006 of the published national application, the terms "visible solution set" and "visible surface determination" have lost their italicization as filed; see WO 2004/046881 A2, p. 3, lines 13 and 15 respectively. Furthermore, in contradistinction to Applicant's published international application, we note that FIG. 3 accompanies the abstract in the title sheet of the published U.S. national application. FIG. 12 was included in the title page of

Applicant's published international application, and FIG. 2 was included in the subsequently republished pamphlet (i.e., the "A3" publication) referencing the International Search Report. It is respectfully requested that in lieu of the general depiction of digital image rendering in a typical computer graphic process of FIG. 3, that **FIG. 11** of the subject application accompany the abstract and other title sheet data upon any republication of the subject application and/or issuance of a letters patent originating from the subject application.

Presently, the specification is amended as indicated, primarily for the sake of clarity and/or readability. In relation to prior prosecutorial efforts, undersigned would appreciate the Examiner's assessment/statement of the condition/status of prior specification/drawing amendments. Finally, undersigned would be pleased to supply a substitute specification (i.e., an offer of substitute specification) pursuant to 37 CFR 1.125 reflecting the subject specification amendments, as well as Applicant's past specification amendments (i.e., those of Attachments A & B).

In the claims, new claims 51-100 are proposed for entry. It is respectfully submitted that new claims 51-99, which depend directly or indirectly from allowed independent claim 31, have been added to round out coverage, and as such, are likewise in condition for allowance. Newly added claim 100 is an independent claim, more particularly, a claim directed to a computer storable medium

storing instructions that when executed by a computer cause the computer to perform a method of photorealistic image synthesis utilizing interval-based techniques for integrating digital scene information within a computer system as recited in allowed independent claim 31. As such, new independent claim 100 is likewise in condition for allowance.

CONCLUSION

For the reasons above, it is respectfully submitted that the subject case, including newly added claims 51-100, is in condition for allowance. Early reconsideration and favorable action are solicited.

Please charge any deficiencies or credit any over payment to Deposit Account 14-0620.

Respectfully submitted,

Nathan T. Hayes

By his attorney

Date 2/20/07

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ATTACHMENT A

IN THE UNITED STATES RECEIVING OFFICE RO/US

International Application No.: PCT/US03/36836

International Filing Date: November 17, 2003

Applicant: Sunfish Studio, Inc.

Title of Invention: SYSTEM AND METHOD OF VISIBLE SURFACE DETERMINATION IN COMPUTER GRAPHICS USING INTERVAL ANALYSIS

Docket No.: 33072/101/111

RESPONSE TO 1ST WRITTEN OPINION

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

CERTIFICATE UNDER 37 C.F.R. 1.10: The undersigned hereby certifies that this paper or papers, as described herein, are being deposited in the United States Postal Service, "Express Mail Post Office to Addressee" having an Express Mail mailing label number of :EV 332 555 407 US, in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on this 27th day of Sept, 2004.

By Laurie E. Gentrup
Laurie E. Gentrup

Dear Sir:

In response to a first WRITTEN OPINION mailed August 20, 2004, please amend the above-captioned PCT application consistent with Art. 34 of the PCT, and the Regulations thereunder, more particularly Rules 46.5 & 66.8, namely the specification and claims, as follows:

IN THE SPECIFICATION

Please amend the specification as indicated, strikeout or double bracketed portions deleted, underlined items added, as applicable, substitute sheets reflecting the proposed changes herewith as **ATTACHMENT A**:

➢Page 1, title:

SYSTEM AND METHOD OF VISIBLE SURFACE DETERMINATION ~~SYSTEM & METHODOLOGY~~ IN COMPUTER GRAPHICS USING INTERVAL ANALYSIS

➢Page 10, only full paragraph thereon should be replaced, so as to now read in its entirety:

With preferred embodiments of the system, an entire scene can be loaded on each computer connected to an output device and synchronously display an image either by sequentially displaying data from each computer, displaying disjoint pieces from each computer, or a combination of both. The system can casually seek edges of objects or transitional areas, i.e., areas with increased levels of information to concentrate the rendering effort. Convergence to the proper visible solution set of a pixel is a deterministic operation which exhibits quadratic convergence (i.e., $0(x^2)$. This is in contrast to point-sampling methods which are probabilistic and exhibit ~~logarithmic~~ square-root convergence (i.e., $0(x^{1/2})$.

➢Page 32, first partial paragraph thereon should be replaced, so as to now read in its entirety:

surface is no longer present in a cell (i.e., cell **X** of FIG. 17(a)). In furtherance thereof, the depth variable, more accurately, depth function, is initialized for all depth space, namely set to the infinite interval [[(]]z depth, i.e., set to an interval at an infinite distance from the viewer, z depth[[)]]. Thereafter, t, u, v, contraction begins in the depth field (z0). Subsequently, there is a trivial accept/reject query as to whether there is in fact a depth component of the x-y parameterization, with searching commencing thereafter (z search). For each depth cell, the importance solver (i.e., the t, u, v, chopper wherein a set inversion is executed in t, u, v so as to contract same) is called upon, and it is necessary to next assess if the shader was invoked. If the shader is invoked (i.e., a first visible root is identified), the output of the shader are accumulated into the importance sums and the depth parsing continues in furtherance of accounting for all z components of the x-y object surface, if not, steps, on a cell by cell basis are "walked off." Although the parsing or chopping of z space has been described as a serial or loop type progression, its is certainly amenable to recursive splitting, as the case of the x-y space.

IN THE CLAIMS

Herewith as ATTACHMENT B, please find substitute/new sheets reflecting the changes proposed herein below, strikeout or double bracketed portions deleted, underlined items added, namely, the amendment of claims 1, 2, 5, 7, 9, 12, 14-17, 19, 22, 25, 27, 28, and 30, the cancellation, without prejudice, of claims 18 and 29, and the addition of new claims 31-50:

1. (Presently Amended) In a photorealistic image synthesis method wherein stored digital representations of physical three dimension object scenes are selectively input, and one or more user-defined shading routines are selectively called upon in the course of assessment of the stored digital representations of physical three dimension scenes in furtherance of the production of a rectangular output array of pixels representing the visible set of surfaces of each of the stored digital representations of physical three dimension scenes, the step comprising:

a. executing an interval branch-and-bound method to compute shading values for pixels, to a user specified certainty, of the rectangular output array of pixels representing the visible set of surfaces of each of the stored digital representations of physical three dimension scenes by successively splitting each object of the objects of the physical three dimensional object scenes, said each object

having a surface delimited by a ~~geometric primitive~~ non linear function.

2. (Presently Amended) The photorealistic image synthesis method of claim 1 wherein said ~~geometric primitive~~ non linear function is ~~a~~ parametric ~~function~~.

3. (Original) The photorealistic image synthesis method of claim 2 wherein an interval analysis is performed over a parametric domain of said each object of the objects of the physical three dimensional object scenes.

4. (Original) The photorealistic image synthesis method of claim 3 wherein consistency is evaluated against a domain of a screen coordinate system.

5. (Presently Amended) The photorealistic image synthesis method of claim [[2]] 1 wherein unknown parametric variables ~~in a system~~ of said non linear ~~equations describing each object of the objects of the physical three dimensional object scenes~~ functions are ascertained using interval analysis.

6. (Original) The photorealistic image synthesis method of claim 5 wherein consistency is evaluated against a domain of a screen coordinate system.

7. (Presently Amended) The photorealistic image synthesis method of claim 6 wherein a solution set ~~of~~ for said parametric variables is input to the one or more user-defined shading routines.

8. (Original) The photorealistic image synthesis method of claim 7 wherein an assessment of consistency against said screen coordinate system includes transformation of boxes representing select areas within said local coordinate system into said coordinate system of said screen.

9. (Presently Amended) The photorealistic image synthesis method of claim 8 wherein splitting of said successive splitting each object of the objects of the physical three dimensional object scenes is ~~first~~ performed in x and y dimensions of said domain of a screen coordinate system.

10. (Original) The photorealistic image synthesis method of claim 9 wherein said splitting is terminated upon satisfying a user-specified dimension criteria for either said x or said y dimension.

11. (Original) The photorealistic image synthesis method of claim 10 wherein said user-specified dimension criteria for either said x or said y dimension is a pixel subunit.

12. (Presently Amended) The photorealistic image synthesis method

of claim [[10]] 8 wherein ~~subsequent to termination of said splitting in said x and y dimensions, further~~ splitting is performed in a z dimension.

13. (Original) The photorealistic image synthesis method of claim 12 wherein, for opaque objects, said z dimension is successively split in a direction extending outwardly from a view point so as to find a first root.

14. (Presently Amended) The photorealistic image synthesis method of claim 13 wherein, for transparent objects, said z dimension is ~~further~~ successively split in a direction extending from a user selected distal extremity in said z dimension inwardly toward a view point so as to find all roots.

15. (Presently Amended) The photorealistic image synthesis method of claim [[14]] 8 wherein a set inversion is performed over a parametric domain to ~~sharpen~~ narrow unknown parametric variables.

16. (Presently Amended) The photorealistic image synthesis method of claim 15 wherein, subsequent to said ~~sharpening~~ narrowing of unknown parametric variables, ~~such~~ a box of said boxes representing select areas within said local coordinate system is shaded and sent to said output array of pixels.

17. (Presently Amended) The photorealistic image synthesis method of claim 16 wherein ~~all~~ boxes <u>of said boxes representing select areas within said local coordinate system</u> contributing to an area of a pixel are integrated to generate a single output result for said pixel.

18. (Canceled) The photorealistic image synthesis method of claim 17 wherein integration of said all boxes contributing to an area of a pixel are importance filtered.

19. (Presently Amended) The photorealistic image synthesis method of claim 1 wherein said ~~geometric primitive~~ <u>non linear function</u> is ~~an~~ implicit ~~function~~.

20. (Original) The photorealistic image synthesis method of claim 19 wherein an interval set inversion is performed over a domain of a screen coordinate system.

21. (Original) The photorealistic image synthesis method of claim 20 wherein, in furtherance of assessment of consistency against said screen coordinate system, boxes representing areas in a local coordinate system are transformed into said coordinate system of the screen.

22. (Presently Amended) The photorealistic image synthesis method

of claim 21 wherein splitting of said successive splitting each object of the objects of the physical three dimensional object scenes is ~~first~~ performed in x and y dimensions <u>of said domain of a screen coordinate system</u>.

23. (Original) The photorealistic image synthesis method of claim 22 wherein said splitting is terminated upon satisfying a user-specified dimension criteria for either said x or said y dimension.

24. (Original) The photorealistic image synthesis method of claim 23 wherein said user-specified dimension criteria for either said x or said y dimension is a pixel subunit.

25. (Presently Amended) The photorealistic image synthesis method of claim 22 wherein ~~subsequent to termination of said splitting in said x and y dimension, further~~ splitting is performed in a z dimension.

26. (Original) The photorealistic image synthesis method of claim 25 wherein, for opaque objects, said z dimension is successively split in a direction extending outwardly from a view point so as to find a first root.

27. (Presently Amended) The photorealistic image synthesis method of claim 26 wherein, for transparent objects, said z dimension is

~~further~~ successively split in a direction extending from a user selected distal extremity in said z dimension inwardly toward a view point so as to find all roots.

28. (Presently Amended) The photorealistic image synthesis method of claim 27 wherein ~~all~~ boxes <u>of said boxes representing select areas within said local coordinate system</u> contributing to an area of a pixel are integrated to generate a single output result for said pixel.

29. (Canceled) The photorealistic image synthesis method of claim 28 wherein integration of said all boxes contributing to an area of a pixel are importance filtered.

30. (Presently Amended) A system for visible surface determination in furtherance of photorealistic rendering in a computer graphics environment, said system comprising:

a. a scene database wherein visual characteristics of objects of an image frame of a scene of said scene database are delimited as geometric ~~primitives~~ <u>functions</u> and,

b. a processor for executing an interval analysis, to a user degree of certainty, for accurately and deterministically ascertaining a visible solution set of an area not exceeding a pixel dimension for a pixel of an array of pixels that form said image frame.

31. (New) A method of photorealistic image synthesis utilizing interval-based techniques for integrating digital scene information comprising the steps of:

a. executing an interval analysis upon input parameters of an image frame so as to compute a visible solution set of an area not exceeding a pixel dimension for a pixel of an array of pixels that form said image frame;

b. computing said visible solution set of the area not exceeding the pixel dimension for the pixel of the array of pixels that form said image frame; and,

c. inputting said visible solution set of the area not exceeding the pixel dimension for the pixel of the array of pixels that form said image frame to a user defined shading function in furtherance of quantitatively assigning a character to the pixel.

32. (New) A photorealistic image synthesis system for constructing and/or reconstructing an image of a digital scene, said system comprising a plurality of hierarchal interval consistency solvers for rigorous computation of a visible solution set of a non linear geometric function representing at least a portion of a pixel of the digital scene, and user defined shading routines mutually dependent upon solvers of said plurality of hierarchal interval consistency solvers, said visible solution set of the non linear geometric function representing the at least a portion of the pixel

of the digital scene being input to said user defined shading routines.

33. (New) A method of visible surface determination in furtherance of rendering an image of a digital scene comprising a series of geometric functions, said method comprising:

a. providing a plurality of interval consistency solvers, said series of geometric functions being sequentially operated upon by solvers of said plurality of interval consistency solvers; and,

b. resolving each parametric variable of parametric variables of each geometric function of geometric functions of said series of geometric functions for each iteration of said each geometric function of said geometric functions of said series of geometric functions.

34. (New) A method of visible surface determination in furtherance of reconstructing two dimensional digital images of a three dimensional digital representation of a visual scene, said method comprising:

a. providing an interval consistency solver input comprising a series of geometric functions defining an element within the visual scene, each geometric function of geometric functions of said series of geometric functions having parametric variables;

b. providing a plurality of interval consistency solvers; and,

c. correspondingly resolving each parametric variable of said parametric variables of said each geometric function of said geometric functions of said series of geometric functions for each iteration of iterations of said each geometric function of said geometric functions of said series of geometric functions during processing of said interval consistency solver input by solvers of said plurality of interval consistency solvers.

35. (New) The method of claim 34 wherein said solvers of said plurality of interval consistency solvers are nested such that a later solver receives as input output of a former solver.

36. (New) The method of claim 34 wherein said iterations of said each geometric function of said geometric functions of said series of geometric functions comprise parsing a two dimensional image plane of the visual scene.

37. (New) The method of claim 34 wherein said iterations of said each geometric function of said geometric functions of said series of geometric functions comprise a set inversion on parametric variables in each of said geometric functions.

38. (New) The method of claim 34 wherein said iterations of said

each geometric function of said geometric functions of said series of geometric functions comprises parsing an x-y image plane of the visual scene.

39. (New) The method of claim 38 wherein said parsing of the x-y image plane includes a set inversion on parametric variables of said each geometric function of said geometric functions of said series of geometric functions.

40. (New) The method of claim 38 wherein, intermediate parsing steps of said parsing of the x-y image plane of the visual scene, said parametric variables of said each geometric function of said geometric functions of said series of geometric functions are resolved.

41. (New) The method of claim 38 wherein for each parsing step of said parsing of the x-y image plane of the visual scene, said each parametric variable of said parametric variables of said each geometric function of said geometric functions of said series of geometric functions are contracted so as to retain only contributing values thereof.

42. (New) The method of claim 40 wherein said iteration of said geometric function of said geometric functions of said series of geometric functions comprises parsing a pixel of the x-y image

plane of the visual scene to a user defined pixel subunit.

43. (New) The method of claim 42 wherein, intermediate parsing steps of said parsing of the pixel of the x-y image plane of the visual scene to a user defined pixel subunit, said parametric variables of said geometric function of said geometric functions of said series of geometric functions are resolved.

44. (New) The method of claim 42 wherein for each parsing step of said parsing of the pixel of the x-y image plane of the visual scene to a user defined pixel subunit, said each parametric variable of said parametric variables of said each geometric function of said geometric functions of said series of geometric functions are contracted so as to retain only contributing values thereof.

45. (New) The method of claim 40 wherein said iterations of said each geometric function of said geometric functions of said series of geometric functions comprise parsing a depth dimension of the two dimensional image plane of the visual scene.

46. (New) The method of claim 45 wherein said parsing of the depth dimension of the two dimensional image plane of the visual scene commences with initialization of a depth function for all depth space.

47. (New) The method of claim 46 wherein, intermediate parsing steps of the depth dimension of the two dimensional image plane of the visual scene, said parametric variables of said each geometric function of said geometric functions of said series of geometric functions are resolved.

48. (New) The method of claim 46 wherein for each parsing step of said parsing of the depth dimension of the two dimensional image plane of the visual scene, said each parametric variable of said parametric variables of said each geometric function of said geometric functions of said series of geometric functions are contracted so as to retain only contributing values thereof.

49. (New) The method of claim 27 wherein a box of said boxes representing select areas within said local coordinate system is shaded and sent to said output array of pixels.

50. (New) The photorealistic image synthesis method of claim 49 wherein boxes of said boxes representing select areas within said local coordinate system contributing to an area of a pixel are integrated to generate a single output result for said pixel.

ATTACHMENT B

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Nathan T. Hayes

Serial No. : N/A — Examiner: Unknown

Filed : Herewith — Group Art Unit: Unknown

For : SYSTEM AND METHOD OF VISIBLE SURFACE DETERMINATION IN COMPUTER GRAPHICS USING INTERVAL ANALYSIS

Docket No. : 33072/101/101

PRELIMINARY AMENDMENT & RESPONSE TO IPER IN U.S. NATIONAL PHASE

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Alexandria, VA 22313-1450

CERTIFICATE UNDER 37 C.F.R. 1.10

The undersigned hereby certifies that this paper is being deposited in the United States Postal Service, "Express Mail Post Office to Addressee" having an Express Mail mailing label number of: EV 629470571, in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on this 27th day of April, 2005.

By: Melissa A. Abeldgaard
Melissa A. Abeldgaard

Dear Sir:

The subject Preliminary Amendment & Response is provided in furtherance of national stage commencement, pursuant to 35 USC §371, of international application PCT/US03/36836 entitled SYSTEM AND METHOD OF VISIBLE SURFACE DETERMINATION IN COMPUTER GRAPHICS USING INTERVAL ANALYSIS, filed November 17, 2003, with a claim of priority to U.S. provisional application ser. no. 60/426,763 filed November 15,

2002. In addition to the preliminary amendment of the subject application, a rebuttal to the International Preliminary Examination Report (IPER or Report) mailed February 28, 2005 is also provided.

Please preliminarily amend the above-captioned patent application consistent with 37 CFR §1.121, effective July 30, 2003, namely the drawings, the specification and claims, as follows:

IN THE DRAWINGS

Herewith as ATTACHMENT A please find "Annotated Marked-up Drawings," consistent with 37 CFR §1.121(d)(1) and labeled as such, showing proposed changes to the figures, more particularly:

➢**a single revised sheet, 7/20, including FIG. 7C, as originally filed, in addition to FIGS. 7(a) and 7(b); and,**

➢**a single revised sheet, 2/20, including FIG. 2, reflecting the substitution of reference numeral 51 for 50.**

IN THE SPECIFICATION

With reference to the published international application, i.e., WO 2004/046881, please amend/replace the below identified paragraph(s) as indicated, strikeout or double bracketed portions deleted, underlined items added:

➢Page 5, the first partial paragraph at line 10, please insert --of-- after "RenderMan in terms" so as to now read as follows:

RenderMan® is the name of a software program created and owned by Pixar that allows computers to render pseudo life-like digital images. RenderMan, a point-sampling global illumination rendering system and subject of U.S. Pat. No. 5,239,624, is the only software package to ever receive an Oscar® award from the Academy of Motion Picture Arts and Sciences. RenderMan clearly represents the current state of the art in pseudo-realistic point sampling software. On the other end of the spectrum, game consoles such as Sony PlayStation® or Microsoft X-Box® clearly do not exhibit the quality of realism found in RenderMan, but these hardware-based local illumination gaming appliances have a tremendous advantage over RenderMan in terms <u>of</u> speed. The realistic frames of animation produced by RenderMan take hours, even days, to compute, whereas the arcade-style graphics of gaming appliances are rendered at a rate of several frames per second.

➢Page 11 and continuing on Page 12, the descriptions with respect to FIGS. 2 and 3 are to be switched, so as to now read as follows:

FIG. 2 ~~is a schematic diagram of the operation of computer graphic process using an existing point-sampling process;~~ is a block diagram of a typical computer graphic process of rendering a digital image;

FIG. 3 ~~is a block diagram of a typical computer graphic process of rendering a digital image;~~ is a schematic diagram of the operation of computer graphic process using an existing point-sampling process;

➢Page 12, in the description with respect to FIG. 11, please insert --i.e., geometric function,-- after "system," so as to now read as follows:

FIG. 11 is a representation as FIG. 10, wherein an exemplary system, i.e., geometric function, and corresponding display are shown;

➢Page 14, the first partial paragraph please insert --(FIG. 1)-- after reference numeral "32" at line 3 thereof; delete reference number "50" at lines 7, 22, and 24; delete reference numeral "41" at line 12; delete reference numeral "43" at line 13; delete reference numeral "45" and "46" at line 14; delete reference numeral "47" at line 15; delete reference numeral "48" at line 16; replace "render farm 49" at line 19 with --network--; and insert reference numeral --51-- after "sequence together" at line 22, so as to now read as follows:

This grid technique is the real world analogy to the computer graphic process that forms the basis of modern day digital graphics. FIG. 2 shows the overall process of how a computer graphics system 40 turns a three dimensional digital representation of a scene 42 into multiple two-dimensional digital images 44. Just

as the artist uses the cells 24 and 32 <u>(FIG. 1)</u> to divide the representation of an entire scene into several smaller and more manageable components, the digital graphics system 40 divides an image 44 to be displayed into thousands of pixels [[50]] in order to digitally display two-dimensional representations of three dimensional scenes. A typical computer generated image used by the modern motion picture industry, for example, is formed of a rectangular array of pixels 1,920 wide and 1,080 high. In a conventional digital animation process, for example, a modeler [[41]] defines geometric models [[43]] for each of a series of objects in a scene. A graphic artist [[45]] adds light, color and texture features [[46]] to geometric models of each object and an animator [[47]] then defines a set of motions and dynamics [[48]] defining how the objects will interact with each other and with light sources in the scene. All of this information is then collected and related in the scene database 42. A ~~render farm 49~~ <u>network</u> comprised of multiple servers then utilizes the scene database to perform the calculations necessary to color in each of the pixels [[50]] in each frame 44 that are sequenced together <u>51</u> to create the illusion of motion and action of the scene. Unlike the rectangular cells 32 on the artist's paper 30, a pixel [[50]] may only be assigned a single color.

➢Page 14, the second partial paragraph at line 27, please replace reference numeral "60" with reference numeral --22--, so as to now read as follows:

With reference to FIG. 3, like the artist via the viewing position [[60]] 22, the system 40 of FIG. 2 simulates the process of looking through a rectangular array of pixels into the scene from the artists viewpoint. Current methodology uses a ray 62 that starts at the viewing position 60 and shoots through a location within pixel 50. The intersection of the ray with the pixel is called a point sample. The color of each point sample of pixel 50 is computed by intersecting this ray 62 with objects 64 in the scene. If several points of intersection exist between a ray 62 and objects in the scene, the visible intersection point 66 is the intersection closest to the origin of the viewing position 60 of the ray 62. The color computed at the visible point of intersection 66 is assigned to the point sample. If a ray does not hit any objects in the scene, the point sample is simply assigned a default "background" color. The final color of the pixel is then determined by filtering a neighborhood of point samples.

➢Page 21, line 1, please delete the second comma appearing in that line, so as to now read as follows:

Returning back again to the notion of point-sampling, and with reference now to FIGS. 6(a)-(f), FIG. 6(a) represents a single pixel containing four scene objects, with FIGS. 6(b)-(f) generally showing a point-sampling algorithm at work in furtherance of assigning the pixel a single color. As should be readily apparent, and generally intuitive, the color of the pixel might be some kind

of amalgamation (i.e., integrated value) of the colors of the scene objects. In FIG. 6(b), only a single point sample is used, and it does not intersect with any of the objects in the scene; so the value of the pixel is assigned the default background color. In FIG. 6(c), four point samples are used, but only one object in the scene is intersected; so the value of the pixel is assigned a color that is 75% background color and 25% the color of the intersected scene object. In FIGS. 6(d), 6(e) and 6(f), additional point samples are used to compute better approximations (i.e., more accurate representations) for the color of the pixel. Even with the increased number of point samples in FIG. 6(e), two of the scene objects are not intersected (i.e., spatial aliasing: missing objects), and only in FIG. 6(f) does a computed color value of the pixel actually contain color contributions from all four scene objects. In general, point sampling[[,]] cannot guarantee that all scene objects contained within a pixel will be intersected, regardless of how many samples are used.

➢Page 24, line 21, please replace "William Walster, <u>Global Optimization</u> (publ. pending)" with --Eldon Hansen and William Walster, <u>Global Optimization Using Interval Analysis</u>, Second Edition--, so as to now read as follows:

The present invention, in all its embodiments, abandons point arithmetic and point-sampling techniques altogether, and instead turns to an interval analysis approach. First invented and published in 1966 by Ramon Moore, interval arithmetic is a

generalization of the familiar point arithmetic. After a brief period of enthusiastic response from the technical community, interval arithmetic and interval analysis (i.e., the application of interval arithmetic to problem domains) soon lost its status as a popular computing paradigm because of its tendency to produce pessimistic results. Modern advances in interval computing have resolved many of these problems, and interval researchers are continuing to make advancements, see for example ~~William Walster, Global Optimization (publ. pending)~~ Eldon Hansen and William Walster, Global Optimization Using Interval Analysis, Second Edition; L. Jaulin et al., Applied Interval Analysis; and, Miguel Sainz, Modal Intervals.

➢Page 28, line 16 please delete "the" after "character," so as to now read as follows:

An output of the interval consistency solvers is indicated as pixel data (i.e., the task of the interval consistency solvers is to quantitatively assign a quality or character to a pixel). The pixel data output is ultimately used in image synthesis or reconstruction, vis-a-vis forwarding the quantitatively assigned pixel quality or character [[the]] to a display in furtherance of defining (i.e., forming) a 2-D array of pixels. For the parameterized system input of FIG. 11, a 2-D array of pixels, associated with a defined set of intervals, is illustrated.

➢Page 29, line 2, insert after "system" --, that is to say, a geometric function--, so as to now read as follows:

The solver, more particularly the most preferred components thereof, namely SCREEN, PIXEL, COVERAGE, DEPTH, and IMPORTANCE, are shown in relation to the input (i.e., dim and system<u>, that is to say, a geometric function</u>), callbacks (i.e., shader), and output (i.e., pixel data and display). The interrelationships between the individual most preferred elements of constituents of the solver, and the general temporal hierarchy between and among each, as well as their relationships between the callbacks (i.e., the shader) and the output (i.e., the display) are schematically shown in FIG. 12. As will be subsequently discussed in the flow schematics for each of the solvers, and as is appreciated by a reference to the subject figure, hierarchical, iterative sieving progresses, in nested fashion, from the screen solver to the importance solver, with each solver exporting a constraint for which the subsequent solver is to act in consideration thereof. Values from successively embedded solvers are returned as shown, the pixel solver ultimately bundling qualities or character of color, opacity, depth, and coverage, for instance, and "issues" such bundled information package (i.e., a pixel reflecting that scene object subtending same) to the display as shown in furtherance of synthesizing the 2-D array corresponding to the image plane.

➢Page 30, line 7 please replace "Chopping" with --Referring now to FIG. 14, chopping--, so as to now read as follows:

~~Chopping~~ <u>Referring now to FIG. 14, chopping</u> of the x-y image plane begins with an initial step analogous to that illustrated in FIG. 19(b). The idea is to parse the x-y image plane to dimensional equate to a pixel. As shown, in the event that initial chopping yields a sub divided x-y area more extensive than a pixel, more chopping is conducted, namely a preferential chopping. More particularly, the nature of the x-y image plane subunit (i.e., a rectangle) is assessed and characterized as being either "landscape" or "portrait". In the event the subunit is landscape, the x dimension is further split: in the event that the subunit is portrait, then the y dimension is then split. For each iterative step in x or y (see FIGS. 19(b) et seq., the arguments t, u, and v, are contracted so as to eliminate values thereof outside the specific or "working" x-y interval (i.e., with each iteration in x and y, it is advantageous to eliminate the t, u, and v values that are not contributing, and thereby potentially contribute to aliasing).

➢Page 32 line 19 replace "its" with --it--, so as to now read as follows:.

The depth solver, as detailed in FIG. 17, is essentially doing the job of FIG. 17(a). More particularly, DEPTH initially ascertains where in the z dimension, ultimately from the image plane (see FIG.

4 camera space), does the object surface, heretofore defined in x, y, t, u, v aspects, first appear or reside (i.e., in which depth cell), and thereafter step into space, via iterative cells, until the x, y, t, u, v object surface is no longer present in a cell (i.e., cell **X** of FIG. 17(a)). In furtherance thereof, the depth variable, more accurately, depth function, is initialized for all depth space, namely set to the infinite interval (z depth). Thereafter, t, u, v, contraction begins in the depth field (z0). Subsequently, there is a trivial accept/reject query as to whether there is in fact a depth component of the x-y parameterization, with searching commencing thereafter (z search). For each depth cell, the importance solver (i.e., the t, u, v, chopper wherein a set inversion is executed in t, u, v so as to contract same) is called upon, and it is necessary to next assess if the shader was invoked. If the shader is invoked (i.e., a first visible root is identified), the output of the shader are accumulated into the importance sums and the depth parsing continues in furtherance of accounting for all z components of the x-y object surface, if not, steps, on a cell by cell basis are "walked off." Although the parsing or chopping of z space has been described as a serial or loop type progression, [[its]] <u>it</u> is certainly amenable to recursive splitting, as the case of the x-y space.

IN THE CLAIMS

Please amend claims 34, 36-45, 47, and 48, stricken out or double bracketed material deleted, underlined material added, as follows, with parenthetical status identifiers provided in relation to the originally filed international application:

1. (Previously presented) In a photorealistic image synthesis method wherein stored digital representations of physical three dimension object scenes are selectively input, and one or more user-defined shading routines are selectively called upon in the course of assessment of the stored digital representations of physical three dimension scenes in furtherance of the production of a rectangular output array of pixels representing the visible set of surfaces of each of the stored digital representations of physical three dimension scenes, the step comprising:

   a. executing an interval branch-and-bound method to compute shading values for pixels, to a user specified certainty, of the rectangular output array of pixels representing the visible set of surfaces of each of the stored digital representations of physical three dimension scenes by successively splitting each object of the objects of the physical three dimensional object scenes, said each object having a surface delimited by a non linear function.

2. (Previously presented) The photorealistic image synthesis method

of claim 1 wherein said non linear function is parametric.

3. (Original) The photorealistic image synthesis method of claim 2 wherein an interval analysis is performed over a parametric domain of said each object of the objects of the physical three dimensional object scenes.

4. (Original) The photorealistic image synthesis method of claim 3 wherein consistency is evaluated against a domain of a screen coordinate system.

5. (Previously presented) The photorealistic image synthesis method of claim 1 wherein unknown parametric variables of said non linear functions are ascertained using interval analysis.

6. (Original) The photorealistic image synthesis method of claim 5 wherein consistency is evaluated against a domain of a screen coordinate system.

7. (Previously presented) The photorealistic image synthesis method of claim 6 wherein a solution set for said parametric variables is input to the one or more user-defined shading routines.

8. (Original) The photorealistic image synthesis method of claim 7

wherein an assessment of consistency against said screen coordinate system includes transformation of boxes representing select areas within said local coordinate system into said coordinate system of said screen.

9. (Previously presented) The photorealistic image synthesis method of claim 8 wherein splitting of said successive splitting each object of the objects of the physical three dimensional object scenes is performed in x and y dimensions of said domain of a screen coordinate system.

10. (Original) The photorealistic image synthesis method of claim 9 wherein said splitting is terminated upon satisfying a user-specified dimension criteria for either said x or said y dimension.

11. (Original) The photorealistic image synthesis method of claim 10 wherein said user-specified dimension criteria for either said x or said y dimension is a pixel subunit.

12. (Previously presented) The photorealistic image synthesis method of claim 8 wherein splitting is performed in a z dimension.

13. (Original) The photorealistic image synthesis method of claim 12 wherein, for opaque objects, said z dimension is successively

split in a direction extending outwardly from a view point so as to find a first root.

14. (Previously presented) The photorealistic image synthesis method of claim 13 wherein, for transparent objects, said z dimension is successively split in a direction extending from a user selected distal extremity in said z dimension inwardly toward a view point so as to find all roots.

15. (Previously presented) The photorealistic image synthesis method of claim 8 wherein a set inversion is performed over a parametric domain to narrow unknown parametric variables.

16. (Previously presented) The photorealistic image synthesis method of claim 15 wherein, subsequent to said narrowing of unknown parametric variables, a box of said boxes representing select areas within said local coordinate system is shaded and sent to said output array of pixels.

17. (Previously presented) The photorealistic image synthesis method of claim 16 wherein boxes of said boxes representing select areas within said local coordinate system contributing to an area of a pixel are integrated to generate a single output result for said pixel.

18. Canceled

19. (Previously presented) The photorealistic image synthesis method of claim 1 wherein said non linear function is implicit.

20. (Original) The photorealistic image synthesis method of claim 19 wherein an interval set inversion is performed over a domain of a screen coordinate system.

21. (Original) The photorealistic image synthesis method of claim 20 wherein, in furtherance of assessment of consistency against said screen coordinate system, boxes representing areas in a local coordinate system are transformed into said coordinate system of the screen.

22. (Previously presented) The photorealistic image synthesis method of claim 21 wherein splitting of said successive splitting each object of the objects of the physical three dimensional object scenes is performed in x and y dimensions of said domain of a screen coordinate system.

23. (Original) The photorealistic image synthesis method of claim 22 wherein said splitting is terminated upon satisfying a user-specified dimension criteria for either said x or said y dimension.

24. (Original) The photorealistic image synthesis method of claim 23 wherein said user-specified dimension criteria for either said x or said y dimension is a pixel subunit.

25. (Previously Presented) The photorealistic image synthesis method of claim 22 wherein splitting is performed in a z dimension.

26. (Original) The photorealistic image synthesis method of claim 25 wherein, for opaque objects, said z dimension is successively split in a direction extending outwardly from a view point so as to find a first root.

27. (Previously Presented) The photorealistic image synthesis method of claim 26 wherein, for transparent objects, said z dimension is successively split in a direction extending from a user selected distal extremity in said z dimension inwardly toward a view point so as to find all roots.

28. (Previously Presented) The photorealistic image synthesis method of claim 27 wherein boxes contributing to an area of a pixel are integrated to generate a single output result for said pixel.

29. Canceled

30. (Previously Presented) A system for visible surface determination in furtherance of photorealistic rendering in a computer graphics environment, said system comprising:

a. a scene database wherein visual characteristics of objects of an image frame of a scene of said scene database are delimited as geometric functions and,

b. a processor for executing an interval analysis, to a user degree of certainty, for accurately and deterministically ascertaining a visible solution set of an area not exceeding a pixel dimension for a pixel of an array of pixels that form said image frame.

31. (Previously Presented) A method of photorealistic image synthesis utilizing interval-based techniques for integrating digital scene information comprising the steps of:

a. executing an interval analysis upon input parameters of an image frame so as to compute a visible solution set of an area not exceeding a pixel dimension for a pixel of an array of pixels that form said image frame;

b. computing said visible solution set of the area not exceeding the pixel dimension for the pixel of the array of pixels that form said image frame; and,

c. inputting said visible solution set of the area not exceeding the pixel dimension for the pixel of the array of

pixels that form said image frame to a user defined shading function in furtherance of quantitatively assigning a character to the pixel.

32. (Previously Presented) A photorealistic image synthesis system for constructing and/or reconstructing an image of a digital scene, said system comprising a plurality of hierarchal interval consistency solvers for rigorous computation of a visible solution set of a non linear geometric function representing at least a portion of a pixel of the digital scene, and user defined shading routines mutually dependent upon solvers of said plurality of hierarchal interval consistency solvers, said visible solution set of the non linear geometric function representing the at least a portion of the pixel of the digital scene being input to said user defined shading routines.

33. (Previously Presented) A method of visible surface determination in furtherance of rendering an image of a digital scene comprising a series of geometric functions, said method comprising:

a. providing a plurality of interval consistency solvers, said series of geometric functions being sequentially operated upon by solvers of said plurality of interval consistency solvers; and,

b. resolving each parametric variable of parametric variables of each geometric function of geometric functions of said series of geometric functions for each iteration of said each geometric function of said geometric functions of said series of geometric functions.

34. (Currently Amended) A method of visible surface determination in furtherance of reconstructing two dimensional digital images of a three dimensional digital representation of a visual scene, said method comprising:

a. providing an interval consistency solver input comprising a ~~series of~~ geometric ~~functions~~ <u>function</u> defining an element within the visual scene, ~~each geometric function of geometric functions of said series of~~ <u>said</u> geometric ~~functions~~ <u>function</u> having parametric variables;

b. providing a plurality of interval consistency solvers; and,

c. correspondingly resolving each parametric variable of said parametric variables of said ~~each~~ geometric function ~~of said geometric functions of said series of geometric functions~~ for each iteration of iterations of said ~~each~~ geometric function ~~of said geometric functions of said series of geometric functions~~ during processing of said interval consistency solver input by solvers of said plurality of interval consistency solvers.

35. (Previously Presented) The method of claim 34 wherein said solvers of said plurality of interval consistency solvers are nested such that a later solver receives as input output of a former solver.

36. (Currently Amended) The method of claim 34 wherein said iterations of said ~~each~~ geometric function ~~of said geometric functions of said series of geometric functions~~ comprise parsing a two dimensional image plane of the visual scene.

37. (Currently Amended) The method of claim 34 wherein said iterations of said ~~each~~ geometric function ~~of said geometric functions of said series of geometric functions~~ comprise a set inversion on parametric variables in each of said geometric functions.

38. (Currently Amended) The method of claim 34 wherein said iterations of said ~~each~~ geometric function ~~of said geometric functions of said series of geometric functions~~ comprises parsing an x-y image plane of the visual scene.

39. (Currently Amended) The method of claim 38 wherein said parsing of the x-y image plane includes a set inversion on parametric variables of said ~~each~~ geometric function ~~of said geometric~~

~~functions of said series of geometric functions~~.

40. (Currently Amended) The method of claim 38 wherein, intermediate parsing steps of said parsing of the x-y image plane of the visual scene, said parametric variables of said ~~each~~ geometric function ~~of said geometric functions of said series of geometric functions~~ are resolved.

41. (Currently Amended) The method of claim 38 wherein for each parsing step of said parsing of the x-y image plane of the visual scene, said each parametric variable of said parametric variables of said ~~each~~ geometric function ~~of said geometric functions of said series of geometric functions~~ are contracted so as to retain only contributing values thereof.

42. (Currently Amended) The method of claim 40 wherein said iteration of said geometric function ~~of said geometric functions of said series of geometric functions~~ comprises parsing a pixel of the x-y image plane of the visual scene to a user defined pixel subunit.

43. (Currently Amended) The method of claim 42 wherein, intermediate parsing steps of said parsing of the pixel of the x-y image plane of the visual scene to a user defined pixel subunit,

said parametric variables of said geometric function ~~of said geometric functions of said series of geometric functions~~ are resolved.

44. (Currently Amended) The method of claim 42 wherein for each parsing step of said parsing of the pixel of the x-y image plane of the visual scene to a user defined pixel subunit, said each parametric variable of said parametric variables of said ~~each~~ geometric function ~~of said geometric functions of said series of geometric functions~~ are contracted so as to retain only contributing values thereof.

45. (Currently Amended) The method of claim 40 wherein said iterations of said ~~each~~ geometric function ~~of said geometric functions of said series of geometric functions~~ comprise parsing a depth dimension of the two dimensional image plane of the visual scene.

46. (Previously Presented) The method of claim 45 wherein said parsing of the depth dimension of the two dimensional image plane of the visual scene commences with initialization of a depth function for all depth space.

47. (Currently Amended) The method of claim 46 wherein,

intermediate parsing steps of the depth dimension of the two dimensional image plane of the visual scene, said parametric variables of said ~~each~~ geometric function ~~of said geometric functions of said series of geometric functions~~ are resolved.

48. (Currently Amended) The method of claim 46 wherein for each parsing step of said parsing of the depth dimension of the two dimensional image plane of the visual scene, said each parametric variable of said parametric variables of said ~~each~~ geometric function ~~of said geometric functions of said series of geometric functions~~ are contracted so as to retain only contributing values thereof.

49. (Previously Presented) The method of claim 27 wherein a box of said boxes representing select areas within said local coordinate system is shaded and sent to said output array of pixels.

50. (Previously Presented) The photorealistic image synthesis method of claim 49 wherein boxes of said boxes representing select areas within said local coordinate system contributing to an area of a pixel are integrated to generate a single output result for said pixel.

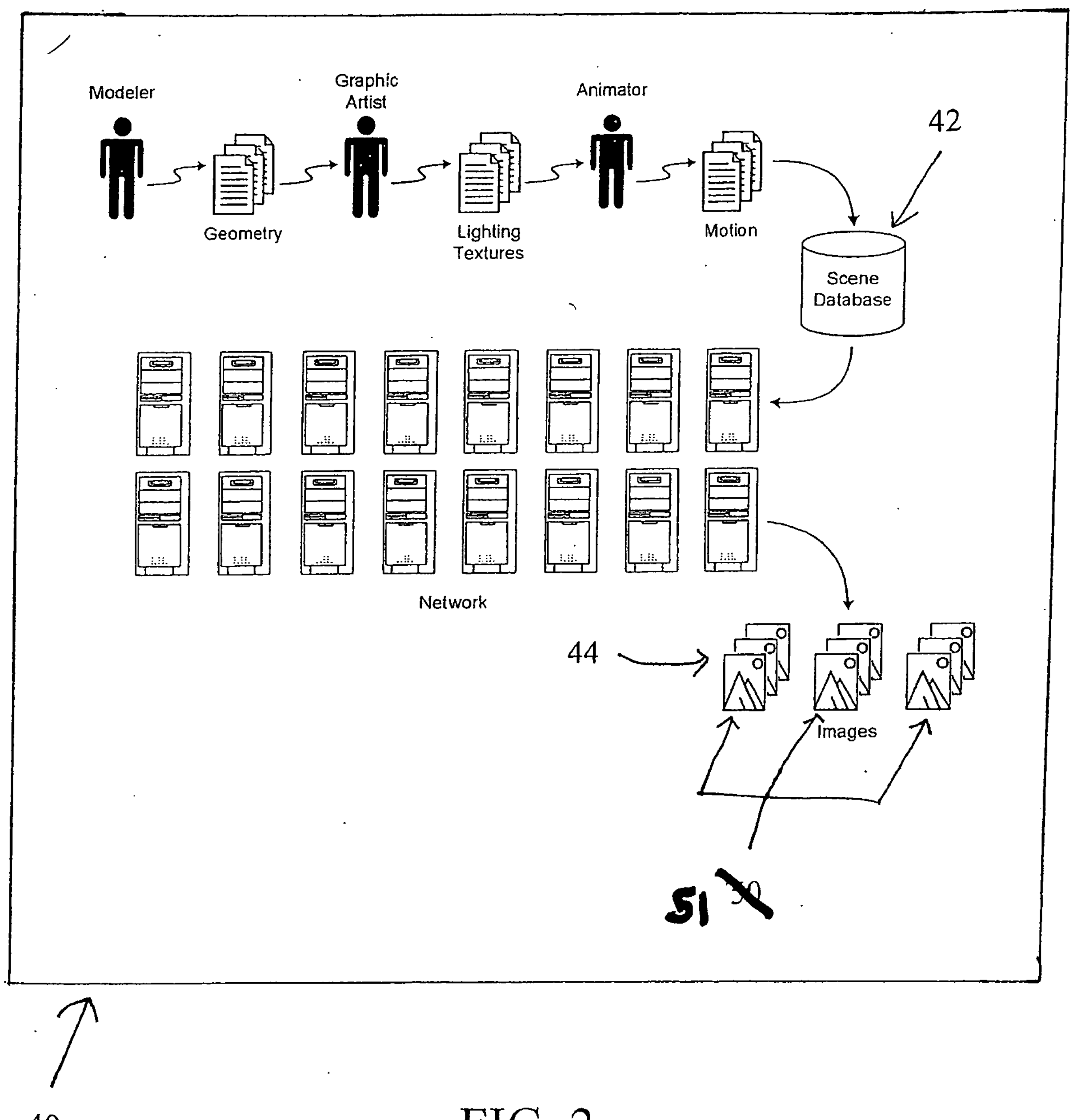
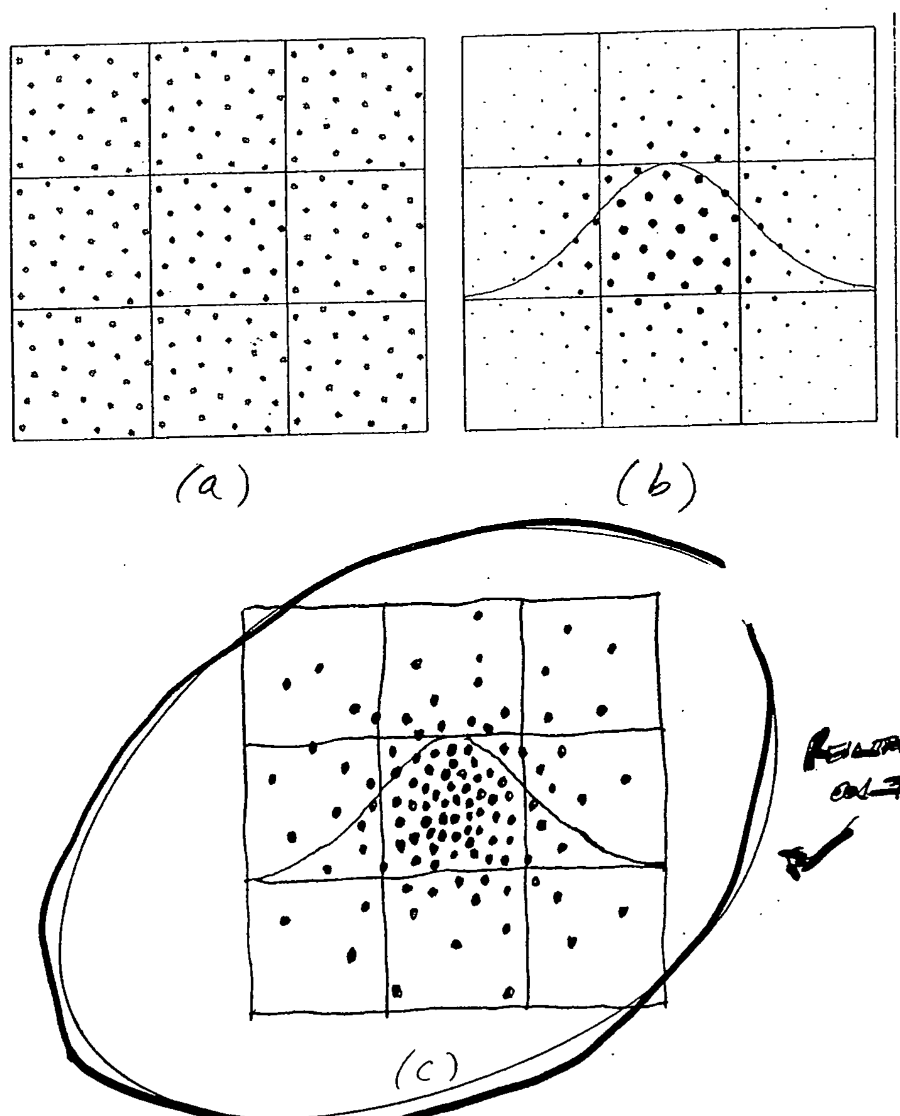

Modeler
Graphic Artist
Animator
42
Geometry
Lighting Textures
Motion
Scene Database
Network
44
Images
51 ~~50~~
40

FIG. 2

ANNOTATED MARKED-UP DRAWINGS

7/20

FIG. 7



(a) (b) (c)

REINTRODUCED, as filed

ATTACHMENT C

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DOCKETED
APR 24 2006
Lynda Eberhard

In re Application of :
HAYES : DECISION ON RENEWED
Application No.: 10/532,907 :
PCT No.: PCT/US03/36836 : REQUEST UNDER
Int. Filing Date: 17 November 2003 :
Priority Date: 15 November 2002 : 37 CFR 1.497(d)
Attorney Docket No.: 33072/101/101/ :
For: SYSTEM AND METHOD OF VISIBLE SURFACE DETERMINATION IN COMPUTER GRAPHICS USING INTERVAL ANALYSIS :

This decision is in response to applicant's "Renewed Petition Under 37 CFR 1.497(d)" filed 30 March 2006 in the United States Patent and Trademark Office (USPTO).

BACKGROUND

On 02 February 2006, applicant was mailed a decision dismissing applicant's request under 37 CFR 1.497(d) to delete Mr. David R. Schmidt as an inventor in the present application. Applicant was afforded two months to respond and advised that this period could be extended pursuant to 37 CFR 1.136(a).

On 30 March 2006, applicant filed the present renewed petition.

DISCUSSION

As discussed in the decision mailed 02 February 2006, 37 CFR 1.497(d) [formally, 37 CFR 1.48] states in part: "If the oath or declaration filed pursuant to 35 U.S.C. 371(c)(4) and this section names an inventive entity different from the inventive entity set forth in the international application....applicant must submit:

(1) a petition including a statement from each person being added or deleted as an inventor that the error in inventorship occurred without any deceptive intention on his or her part;

(2) an oath or declaration by the actual inventor(s) as required by 37 CFR 1.63;

(3) the fee set forth in 37 CFR 1.17(i); and

(4) if an assignment has been executed by any of the original named inventors, the written consent of the assignee in compliance with 37 CFR 3.73(b).

Applicant previously satisfied items (2) and (3); while item (4) did not apply.

As to item (1), applicant has now submitted a statement from Mr. Schmidt avowing that the error in inventorship occurred without any deceptive intention on his part.

As such, it is proper to grant applicant's renewed request at this time.

CONCLUSION

For the reasons above, applicant's renewed request under 37 CFR 1.497(d) is **GRANTED**.

This application will be given an international application filing date of 17 November 2003 and a date of **27 April 2005** under 35 U.S.C. 371(c)(1), (c)(2) and (c)(4).

This application is being returned to the DO/EO/US for processing in accordance with this decision.

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